

Ion Beam Materials Laboratory

The Ion Beam Materials Laboratory (IBML) is a Los Alamos National Laboratory resource devoted to materials research through the use of ion beams. Current major research areas include surface characterization through ion beam analysis techniques, surface modification and materials synthesis through ion implantation technology, and radiation damage studies in gases, liquids, and solids.

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specific apparatus needed for experiments requested by facility users. The result is a facility with competencies in ion beam experiments and the versatility to cater to individual researcher's needs.

An in situ dual ion beam facility provides ion beam irradiation and in situ ion beam characterization. In this facility, an analytical beamline from the 3.2 MV tandem accelerator and an irradiation beamline from the 200 kV ion implanter are connected to a common surface modification chamber. Rutherford backscattering spectrometry (RBS), nuclear reaction analysis (NRA), and particle induced x-ray emission (PIXE) are available in conjunction with ion channeling techniques to monitor in situ changes of composition and crystallinity of materials being irradiated at temperatures from -190 to 500°C.



Tandem ion accelerator

Tandem beam parameters

Proton beam: 200 keV to 6.4 MeV
Alpha beam: 200 keV to 9.6 MeV
Heavy ions: 200 keV to 20 MeV

Beam currents: from ~pA to ~μA
(equivalent to ~mCi to ~thousand Ci radioactive alpha source)

The general purpose experimental station is a highly versatile, easy-to-use chamber for materials analysis using beam-induced x-rays, gamma rays, NRA, RBS, and elastic recoil detection techniques, as well as for high-energy ion implantation. The chamber is equipped with a five-axis, computer-controlled goniometer for sample changing and channeling measurements.

Operated as a part of the Structure/Property Relations Group in the Materials Science and Technology Division, the IBML is the designated ion beam facility for users of the Center for Integrated Nanotechnologies, a DOE nanoscience center jointly operated by Los Alamos and Sandia National Laboratories.

Fast facts

Tritium analysis chamber

Designed to measure hydrogen isotopes (protium, deuterium, and tritium) to metal ratios in metal hydrides as well as oxygen depth profiles in metal hydride targets.



200 kV production ion implanter

High energy alpha beam irradiation chamber

Available to study alpha-induced radiolysis in gases, liquid, and plastics. The in situ residual gas analyzer and infrared absorption spectrometer are available to measure gas emission and formation during the irradiation.

Nuclear microprobe beam line

Provides highly focused proton or alpha beam (a few microns in diameter) for ion beam microanalysis through particle induced x-ray emission, NRA, and microfabrication through high energy proton-beam lithography.

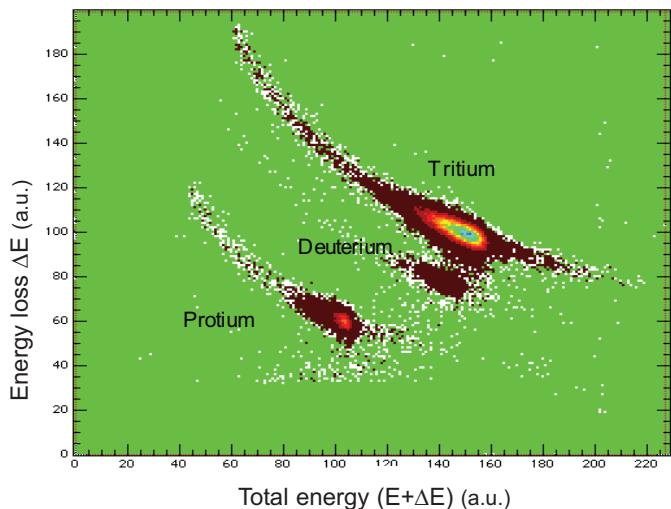
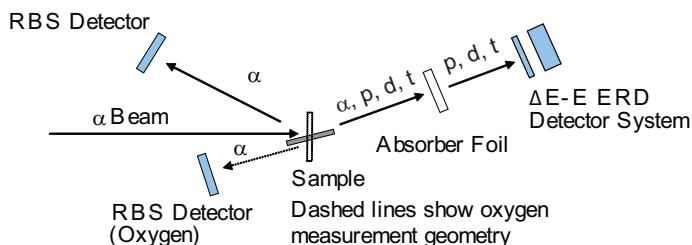
200 kV production ion implanter

Capable of producing many ion species from gases, transition metals, and rare earth metals with a beam current ranging from microamperes to hundreds microamperes. The implantation can be conducted at different temperatures ranging from LN₂ to 1100°C. Typical implantation fluence is from 10¹⁴ to 10¹⁷ atoms/cm².

State-of-the-art research ion implanter

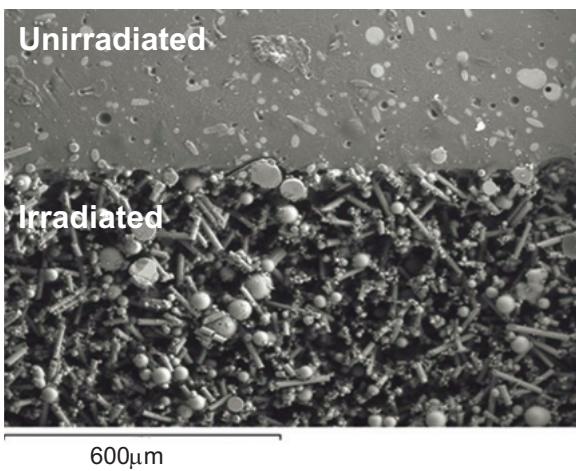
Due to arrive in late 2006, the first of its kind in North America, with a high-current source operates either in gas, vapor, or sputter configuration to produce ion forms from virtually any element in the periodic table. Typical operation will be from 5 to 200 kV, but could offer up to 800 keV implants with multiple-charged ions. A semiconductor beam line allows a large span of fluences (10¹² to 10¹⁷ ions/cm²) to be implanted into as large as 8-inch wafers. An optional high-current beamline with target heating and cooling capability can be added. With this add-on, much high fluences such as 10¹⁹ to 10²⁰ atoms/cm² implants could be achieved over an area of 1-inch squared in a couple of hours. Since ion implantation is a non-equilibrium process in which energetic ions of atomic species interested are forced to mix with target species, the formation of new phases or structures that conventional physical or chemical processes could not achieve is to be expected.

Ion Beam Materials Laboratory areas of research



Hydrogen isotope/metal ratio analysis:

Above, basic principle of ion beam analysis process and hydrogen spectrum of a tritiated metal film.



Structural compatibility study of actinide alpha irradiation degradation of silica reinforced Teflon, induced by 5 MeV alpha-beam irradiation.

Materials Characterization

with Ion Beam Analysis Techniques

- Rutherford backscattering spectrometry (RBS): used extensively for quick and accurate measurement of elemental composition and impurity distributions in thin films and interfaces. Trace actinide measurements with sensitivities up to a few nanograms per square centimeter.
- Elastic recoil detection analysis: a complementary scattering technique to RBS for easy depth profiling of hydrogen isotopes (H, D, and T) and helium isotopes in surfaces and thin films.
- Nuclear reaction analysis: provides high sensitivity measurements of light elements (H, D, ^3He , Li, B, C, O, F) and their depth profiles in high Z substrate.
- Particle induced x-ray emission (PIXE): a nondestructive, quantitative and multi-elemental analysis technique for trace elements with an excellent detection limit (~ppm) and superb mass resolution. Applications include toxic elements measurements in water (As, Pb, Cr, etc.).
- Ion channeling: ion channeling effect assesses quality and orientation of single crystalline thin films, including the location of impurity atoms in the lattice sites as well as radiation damage introduced in single crystals by ion implantation.

Materials Modification and Synthesis

with Ion Implantation

- Precipitation of nanoparticles from implanted immiscible elements.
- Materials that are defect engineered with ion irradiation to alter mechanical, electrical and optical properties and to control the diffusion of dopants.
- The use of ion implantation to cleave nanolayers of materials for the functional integration of dissimilar materials.
- Optical, tribological, and other protective coatings formed by ion implantation of bulk materials.
- The tailoring of surface and/or interface stress through ion bombardment.
- The use of ion implantation to enhance film to substrate adhesion.

Radiation Damage Effects

- Alpha radiolysis of gases, liquids, and polymers used in weapons' applications and nuclear waste management.
- Proton beam irradiations to simulate neutron radiation damage in materials used in nuclear reactors.
- Radiation effects in ceramics and semiconductors.
- Calibration of satellite-based detectors with accelerator ion beams.
- Aid understanding of plutonium aging phenomena.
- Radiation tolerance in nanostructured materials